The International Lunar Network Anchor Nodes Mission: An Update

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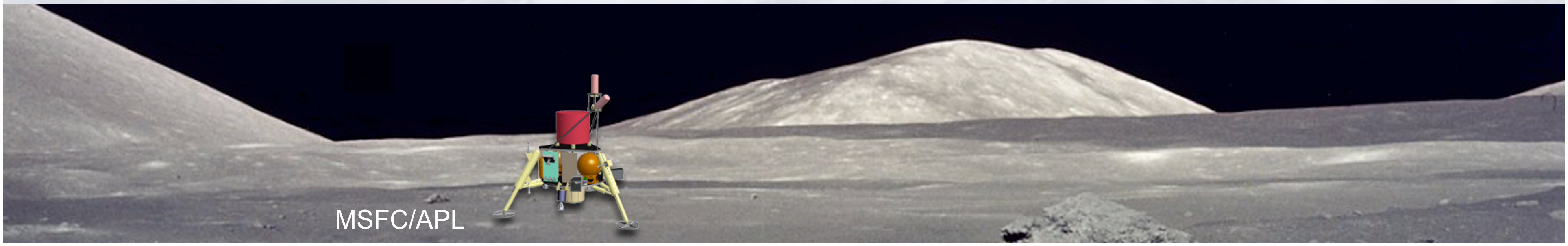
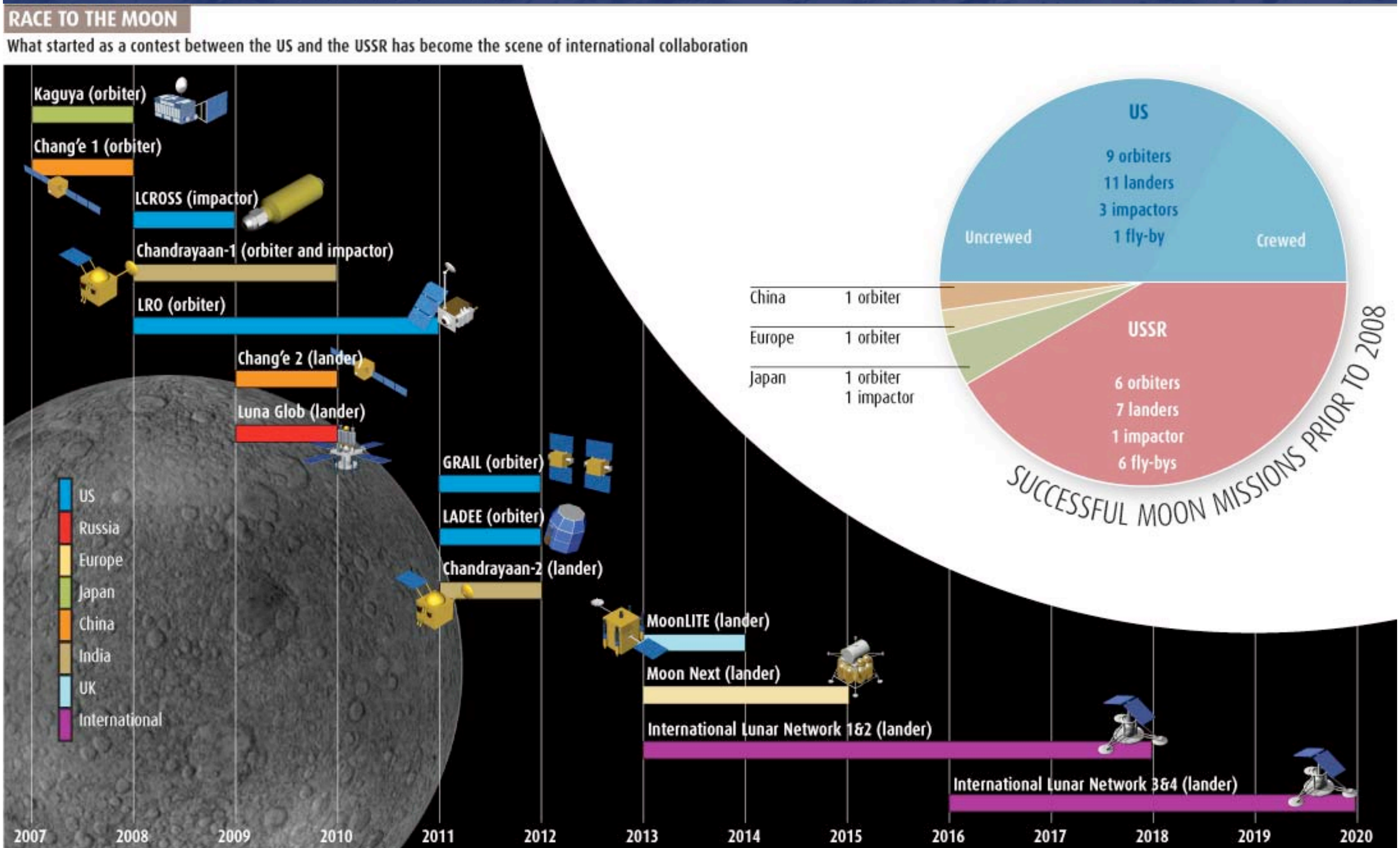
on behalf of the **ILN Science Definition** and **Engineering Teams**,
including many contributions from the SDT and the science community

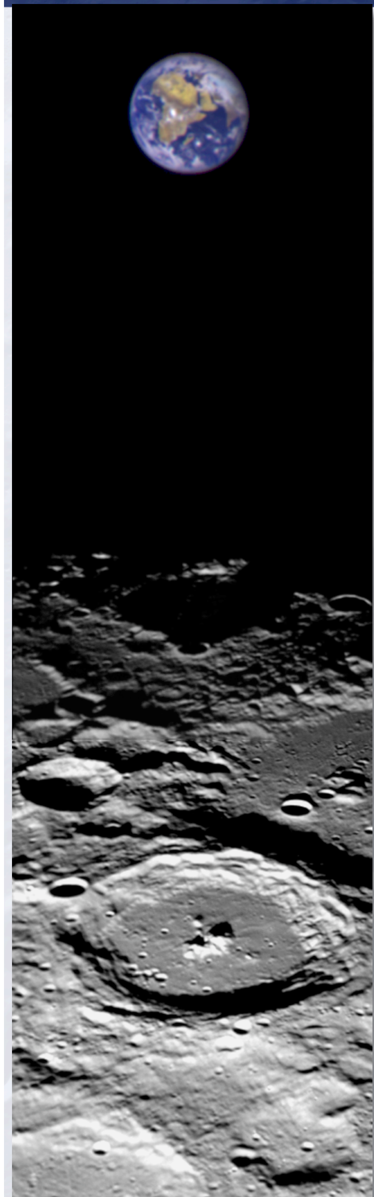


Robotic lunar missions



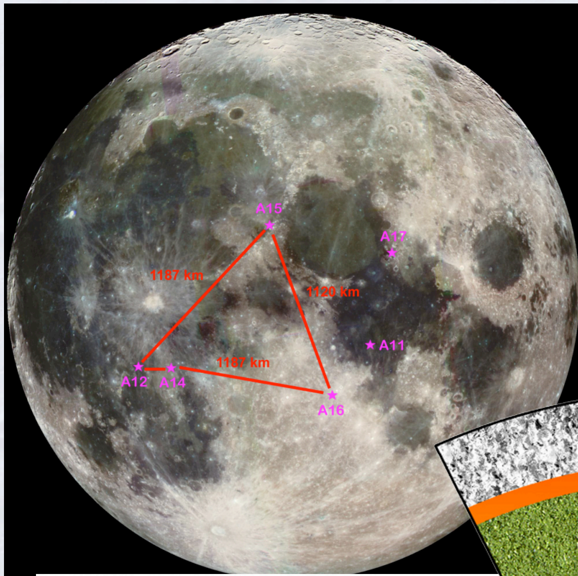
D. Mackenzie, New Scientist, July 11 2008

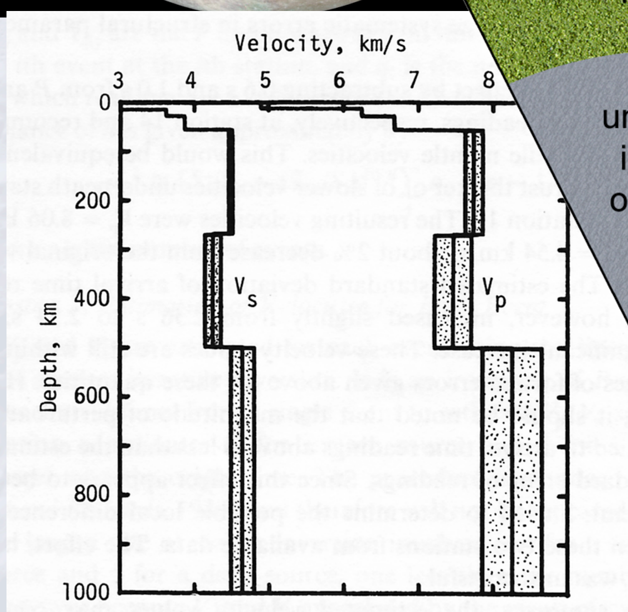
The Moon is a terrestrial planet

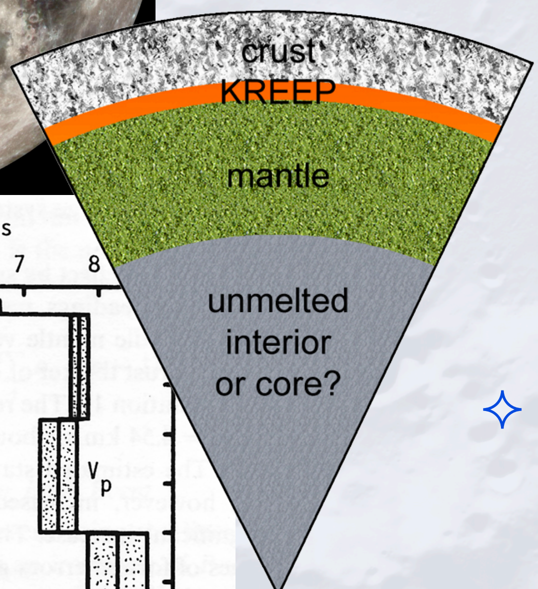


- The Moon today presents a record of geologic processes of early planetary evolution:
  - Interior retains a record of the initial stages of planetary evolution
  - Crust has never been altered by plate tectonics (Earth), planetwide volcanism (Venus), or wind and water (Mars & Earth)
  - Surface exposed to billions of years of volatile input
- The Moon holds a unique place in the evolution of rocky worlds - many fundamental concepts of planetary evolution were developed using the Moon
  - The Moon is ancient and preserves an early history
  - The Moon and Earth are related and formed from a common reservoir
  - Moon rocks originated through high-temperature processes with no involvement with water or organics

The Moon is a differentiated planet

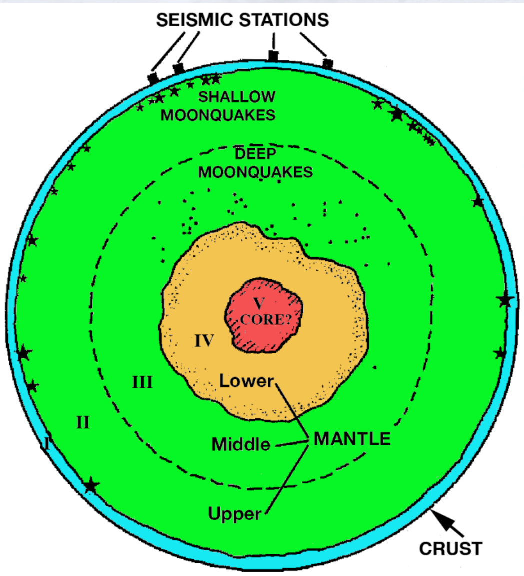


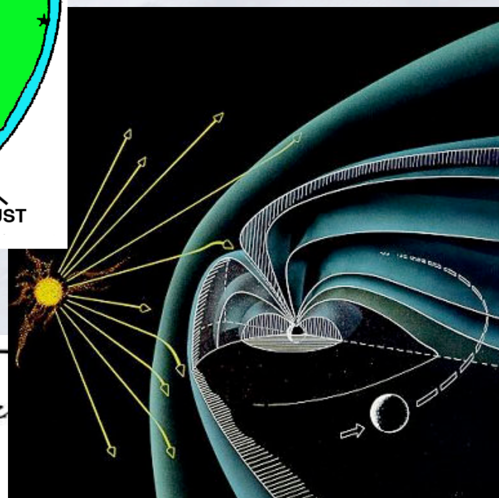


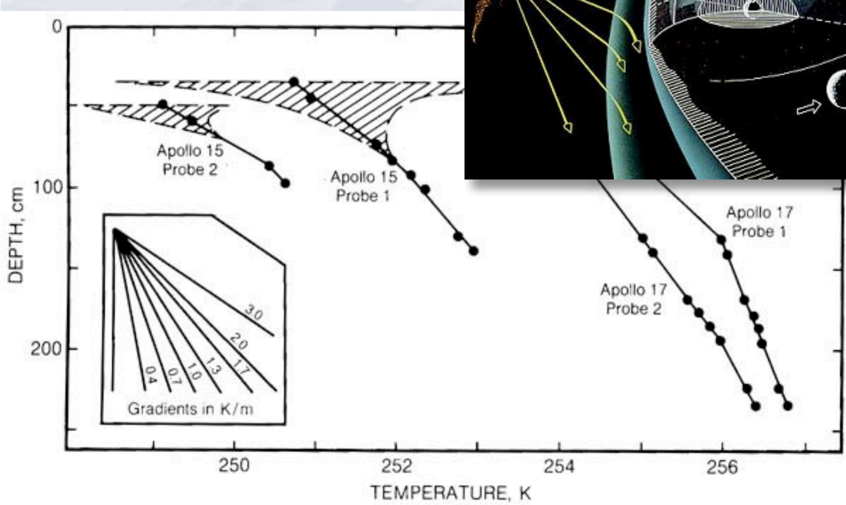


- Crust on near side is 30-40 km thick, far side is thicker (60 km); it is broken up to 10's of km; lateral variations exist
- LMO hypothesis says that a mantle exists; geochemical arguments hypothesize that it is layered and different composition than Earth's; possible seismic discontinuity at ~500 km on the lunar nearside
- Magmatism was most active > 3 Ga, heat flow in the mantle was higher in the past
- Probably a small (250-350 km) core

The Moon is an active planet







- 28 recorded shallow moonquakes (~1 magnitude 5 or greater event per year).
- >7000 deep moonquakes in 8 years from unique “nests”
- Heat flow from decaying radioactive elements
- Induced magnetic fields from solar wind interaction and passage through the Earth’s magnetotail
- Libration due to interior structure

ILN mission objectives

The goal of a Lunar Geophysical Network is to understand the interior structure and composition of the Moon

- Determine the size, composition, and state (solid/liquid) of the core of the moon.
- Characterize the thermal state of the interior and elucidate the workings of the planetary heat engine.
- Characterize the chemical/physical stratification in the mantle, particularly the nature of the putative 500-km discontinuity and the composition of the lower mantle.
- Determine the thickness of the lunar crust (upper and lower) and characterize its lateral variability on regional and global scales.

The next generation of geophysical measurements have to improve on current knowledge by having a wider geographical placement, more sensitive instrumentation, and a longer baseline of observations

ILN Anchor Nodes mission

- Emplace two geophysical nodes onto the lunar surface as anchor nodes for the International Lunar Network.
  - Launch 2012-2014, depending on resource availability
  - Mission cost capped at $200M life cycle cost - Category III, Class D
  - Provider: MSFC and APL; leverage previous concept designs and studies from MSFC, APL, JPL, ARC and DOD
  - Launch Vehicle: both nodes and delivery system launched on a single vehicle (Minotaur, Falcon, or existing EELV launch)
  - Instruments competitively selected
- Pre-Phase A through October 2008
  - Independent Concept Evaluation Team: establish database of capabilities & hardware from ARC, JPL, DoD, industry and academia
  - Science Definition Team set mission goals & measurement objectives
  - APL & MSFC develop mission design concepts
  - Mission Concept Review in October 2008 (tentative)

Anchor Nodes SDT

- ILN Anchor Nodes Science Definition Team:

  Joe Veverka, Cornell, & Barbara Cohen, MSFC, co-chairs

Bruce Banerdt, JPL	Andrew Dombard, UIC	Lindy Elkins-Tanton, MIT
Bob Grimm, SWRI	Yosio Nakamura, UT Austin	Clive Neal, UND
Jeff Plescia, APL	Sue Smrekar, JPL	Ben Weiss, MIT

- The clear focus of the SDT is to address what science is uniquely enabled by the synergy of a network, within the context provided by previous community based activities (SCEM, Tempe, NRESS, etc.)
- Chartered 03/08; multiple telecons and 1 in-person meeting – charge to the committee, state of the science/instrumentation, formulation and prioritization of science and measurement goals, science baseline and floors
- Interim report delivered to the Planetary Science Division Director 7/17/08. Final report due 8/31/08.

SDT interim findings

- **Seismometry** is uniquely enabled by a network mission. **Heat flow** measurements, **EM sounding**, and **laser reflectometry** are highly complementary measurements at each site.
- *Science Baseline:* Understand the interior structure and composition of the moon using multiple geophysical analyses at each of 4 locations on the Moon, operating simultaneously and continuously for one lunar tidal cycle (6 years)
- *Science Floor:* Determine the deep interior velocity structure of the Moon and place constraints on the core size/density by operating 2 broadband seismometers simultaneously and continuously for 2 years - only enabled by specific site selection (nonpolar)
- Additional (international) nodes make the network greater than the sum of its parts – maximizing science return while minimizing the required contribution from each space agency
- Synergy exists among SMD, ESMD (surface plasma environment, hazard avoidance), and SOMD (comm sat, laser comm testing)

Design concept studies

- Four design concepts carried forward to the APL ACE lab for intensive design sessions and cost scoping
  - Floor mission on a soft lander
  - Baseline mission on a soft lander
  - Baseline mission on "hard" landers (crushable and penetrator)
  - Single landers on Minotaur V – class launch
- Technical Peer Review of design concepts in first two weeks of August
- SDT Interchange meeting on 8/7
- Refine designs and costs through end of Pre-Phase A / MCR

Summary

- The ILN concept provides an organizing theme for US and International landed science missions in the next decade - each ILN node will make a core set of measurements requiring broad geographical distribution on the Moon
- The ILN geophysical network will dramatically enhance our knowledge regarding the internal structure and composition of the Moon, as well as yield important knowledge for the safe and efficient construction and maintenance of a permanent lunar habitat
- The US intends to provide Anchor Nodes for the ILN, currently two nodes under design for launch in ~2012-2014 – the first US robotic lunar landers since 1968
- There is fundamental and exciting science that can be accomplished by a relatively large ILN missions with relatively small ILN nodes